3.4.7 Great Lakes Region

Participants in the Great Lakes region workshop consisted mainly of representatives from educational institutions and local government. One of the principal interests of the group was exploration of seasonal change, species change, feeding rates, and identification and characterization of transitions occurring in represented biota. This interest was labeled as the discovery and understanding of seasonal change in "one cubic meter of water." The group emphasized the need to understand the interactions between different biota based on the lake origin and species biodiversity. Exploration of the influence of surface and benthic storms on the distribution of nutrients biomass and currents was also discussed.

The workshop participants felt that additional efforts should be made in archeological survey to locate and document submerged cultural resources such as shipwrecks, ancient communities, and paleo-shorelines as a precursor to the management and preservation of these resources.

Additional discussions centered on the importance of the Great Lakes as a reservoir for fresh water. Participants talked in length about the value in exploring the world's largest lakes (based on size) and comparing their biodiversity and genetic connectivity to the Great Lakes. The group proposed using the closed system of the Great Lakes to develop and prototype oceanographic models. They pointed out that this application would provide fewer logistical and resource challenges when compared to the open ocean explorations. Attendees pointed out the lack of high resolution maps for locating unique geological features (and habitats) including karsts, ring depressions, and ridge systems.

The group stressed the importance on understanding the Lakes during the winter when large areas are ice covered. Exploration under the ice in winter has been limited—similar to the Alaska region—and as a consequence the impact of ice cover on ecosystems and habitats is generally unknown.

Several participants felt that the Great Lakes are often overlooked in relation to ocean areas and that people living in the central U.S. are not as connected to the oceans. Projects involving the Great Lakes were also viewed as a method for reaching out and connecting with this constituency. Several participants discussed the need for a more

coordinated outreach program. One idea was the allocation of a Class I vessel as the lead ship for a multi-ship exploration expedition. Other methods included the pooling of efforts among academia, local government, and industry to raise awareness among K-12 students and the public.

Results from the Great Lakes region workshop are provided in Table 3-9. Exploration targets of interest are illustrated in Figure 3-9.

Table 3-9. Great Lakes Region Workshop Results

Great Lakes Workshop	
Standard Package: Class I/II/III/IV Vessel with acoustic mapping; Dive capability (ROV / AUV / Submersible) with imagery / video and sampling equipment; Precise positioning system; Walk-in cold room (4 degrees); Sea water system; Flux / aerosol / optical / meteorological sampling system	**Standard Partners:** EPA; Great Lakes Environmental Research Laboratory (GLERL); Ohio State University; Grand Valley State University; Canadian Center for Inland Waters; Canadian Dept of Defense & Coast Guard; Great Lakes WATER Institute; University of Michigan; Large Lakes Observatory; Michigan Tech; USGS; Coast Guary; University of Toronto; Illinois Natural History Survey; Departments of Natural Resources; NASA; WHOI; NSF; HBOI; National Geographic; Navy; USACE

Great Lakes Workshop Results						
ID	**Category**	**Information Need/Gap**	**What**	**Where**	**Enabling Technologies**	**Partners**
274	Archeology	Cultural resources; paleo-archeology of basin and human interactions -	Identify shipwrecks; Submerged shorelines; paleolake lines; ID sites; location; archeological documentation	All the Great Lakes basin wide; Green Bay; Saginaw Bay - Deep Water; Nearshore Karst features; Straits of Mackinaw Island; Submerged river mouths; Paleolake levels	Standard Package; sea water systems; predictive modeling; sidescan sonar; better/ faster multibeam systems	Standard Partners
281	Archeology	Archeological survey and documentation	Location; documentation; evolution of marine technology; 19th century; effects on biology (good time measurement); influence of currents; also look at known wreck sites; broad based survey; then document important sites; search for existing data then document sites (model storm data)	Throughout Great Lakes; deep water; Lake Michigan; Thunder Bay (already have resources) Lake Champlain; Lake Superior; Death's Door; ports; Keweenaw Peninsula; Nearshore Karst features; Straits of Mackinaw; submerged river mouths; paleo-lake levels	Standard Package; technical divers; acoustic/laser vision system; magnetometer; modeling lake level studies and Interactive (w/ public) cameras; ROVs; multibeam; sub-bottom profilers; magnetometer; LIDAR; deep diving cold water diving; active acoustics; moored sensors & instrumentation; time lapse video; divers (SCUBA); reef design	East Carolina University, museums, historical societies, industry, philanthropy, Thunder Bay National Marine Sanctuaries, Office of Naval Research; Smithsonian; academia, Native American groups; University of Waterloo, Fish & Wildlife Service, tourism, recreational divers, University of Windsor

Great Lakes Workshop Results						
ID	**Category**	**Information Need/Gap**	**What**	**Where**	**Enabling Technologies**	**Partners**
293	Artificial Habitats	Artificial reefs	Recruitment; deterioration of cultural material; environmental effect; new vs. used; lab	Artificial reef sites e.g. not too much fishing or commercial activity	Standard Package; Moored sensors & instrumentation; time lapse video; divers (SCUBA); reef design; Active acoustics	Standard Partners; industry; Department of Natural Resources (DNR); University of Waterloo; Fish &Wildlife Service; tourism; recreational divers; University of Windsor
275	Benthic Environment	Benthic communities - "Things that live between the rocks"	Limited sampling of difficult areas; deep reef systems; out crop reefs; Identify & characterize interaction; effects of exotics; impact of fisheries; compare w/ oceans; food web	National & International; Large Lake Areas; Lake Superior; compare with Chesapeake Bay and Gulf of Maine	Miniaturized exploration / sampling techniques; fiber optics & subs; ROV's; AUV's; dynamic positioning systems; small cameras & fiber optics; sucking mechanisms; different type of new technologies for sampling techniques for heterogeneous area; sensors with ability to describe the physical substrate in three dimensional sense; long term video observation platform; time lapse cameras	Standard Partners, Camera Manufacturers; SIO; industry (esp. finances - power plants, fishing, fishing support); boating industry; Sea Grant Extension (outreach & funding); Jason Project
283	Benthic Environment	Benthic communities	ID & characterize interaction; effects of exotics; impact of fisheries; compare w/ oceans; food web	Lake Superior; compare with Chesapeake Bay and Gulf of Maine	Standard Package; ROVs; Subs; sampling; AUVs; acoustic scanner; long term video observation platform & time lapse cameras	Standard Partners; SIO; industry (esp. finances - power plants, fishing, fishing support); boating industry; Sea Grant Extension (outreach & funding); Jason Project

Great Lakes Workshop Results						
ID	**Category**	**Information Need/Gap**	**What**	**Where**	**Enabling Technologies**	**Partners**
271	Boundary Fluxes - Air/Sea	Linkage in the atmospheric forcing function	Forcing functions in atmosphere; air/sea interaction for the exchange of gas mass constitutes; across all lakes; temperature; current; wind speed; barometric pressure; real time chemical composition (monitor 5 places in one of the large lakes; see how lake responded over two years and choose detailed location and study eddies and zooplankton modeling); application for marine boundary levels influences; different processes to study and couple to ocean processes cores and eddy's (rings)	Ten largest lakes in the world; Lake Michigan (start where there are problems); need to be strategically positioned; Lake Champlain; Yellowstone Lake then translate atmosphere studies techniques for application into the ocean environment	Standard Package; Buoys; ADCPs; various sensors; mass spectrometer; wireless comms; real-time web access; instrumented moorings; drift buoys; instrument arrays; acoustic imaging; sediment traps New Measurement techniques (RADAR or LIDAR)	Standard Partners
294	Boundary Fluxes - Air/Sea	How climate varies in space & time	Climate Change on Timescales of Decades to Millennium	African Rift Lakes; other large lakes of tectonic origin	Drilling; Heave compensation and dynamic position or deep water anchoring	Standard Partners
288	Boundary Fluxes - Basins	Carbon cycling in lakes	Carbon cycling; primary productivity; Carbon accumulation; Carbon consumption; compare among lakes	Lake Superior; Lake Michigan vs. other lakes	Standard Package; AUVs; primary prod techniques; sediment traps	Standard Partners
272	Currents & Water Masses	Discover new bio / geo /chemical pathways (distribution in the physical sense)	Identify pathways for compounds	Least likely place	Indicator compounds exploration; measurement systems; platforms for opportunities; next generation of "FLIP"; smart sensors; swath vessel; remote sensing; super computer	Navy, Energy Industry, Marine Transportation; National Weather Service; Canada

Great Lakes Workshop Results						
ID	**Category**	**Information Need/Gap**	**What**	**Where**	**Enabling Technologies**	**Partners**
279	Currents & Water Masses	Coupling of modeling and measurements; sample strategy/ bio / currents / atmosphere models - models can drive questions researchers to answers	Areas of gradients (where do you put the resources) at biologically dynamic areas	Identification models to lead to examples (NASA sulfur model)	Using cruise ships and instruments (car ferry towing instruments) acoustics; sampling water; image shadow image analysis; microwave radar on bow of ship to measure surface roughness; small scale of hyperspectral imaging; environmental tracers; miniaturized exploration / sampling techniques; fibre optics & Subs; ROV's; AUV's; dynamic positioning systems	WHOI, Harbor Branch; National Geographic
285	Currents & Water Masses	Mesoscale eddies - frequencies & importance; current flow patterns, eddies, mixing process, impact on bio, frequency & importance to ecosystems productivity, chem props	Current flow patterns; eddies; mixing process; impact on bio; frequency & importance to ecosystems productivity; chem props	Lake Superior; other Great Lakes; Yellowstone Lake	Standard Package; current meters; satellites; ADCP moorings; instrumented moorings; drift buoys; ADCPs; instrument arrays; acoustic imaging; sediment traps	Standard Partners, University of Toronto, Oregon State University, Scripps, WHOI
291	Ecosystem - Karst / Ring Depressions	Karst features in Lake Huron (sinkholes)	Spatial coverage; depth; dimensions; biology; chemistry; local flow pattern	Central Lake Huron	Standard Package; miniaturized exploration / sampling techniques; fibre optics & Subs; ROV's; AUV's; dynamic positioning systems; mass spectrometer	Standard Partners
292	Ecosystem - Karst / Ring Depressions	Ring depressions (400-500 m across; 20-30m deep)	How they formed; influence on distribution of benthic communities; sediments; contaminants; local flow patterns; why not in other lakes	Lake Superior	Standard Package; seismic reflection profiling; ROVs; sediment coring; subs	Standard Partners

Great Lakes Workshop Results						
ID	**Category**	**Information Need/Gap**	**What**	**Where**	**Enabling Technologies**	**Partners**
267	Ecosystem - Lakes	Lake Biodiversity	Bio / geo / chemical processes; origin of lakes; origin of species (evolutionary processes); community structures & compositions; species diversity - looking for new species; (3 african great lakes); rapid assessment survey; collection of long term sediment cores; geo-thermal vents systems; describe landscape census; looking for midwater scatters; multibeam survey; physical ocean sampling; natural history survey	Bia Kal Lake; African Rift Lakes; Lake Nicquragua; Great Bear; Great Slave Lake; Titikacica Lake; Yellowstone	Standard Package; ROVs / AUV / SCUBA / submersibles / hyperspectrual remote sensors; in-situ sensor (long term); small vessel for estuaries: digital imagery; high frequency mid-level acoustic census	USGS; Country of Lake; Smithsonian; United Nations Environment Programme (UNEP); developing nations organizations; DOI, USGS; museums
277	Ecosystem - Lakes	Recharge of the all component parts lake systems	Use of streams for spawning; ecosystems approach to water quality; examine revival of species; pollutants	Test cases in Southeast Wisconsin; collaborative efforts with Canada & other international entities	Standard Package; miniaturized exploration / sampling techniques; fiber optics & subs; ROV's; AUV's; dynamic positioning systems; modeling technologies; maintenance of USGS gauge stations; broad scale monitoring	WHOI, Harbor Branch; National Geographic
290	Ecosystem - Seamounts / Ridges	North/south ridges in Lake Superior	Origin controversy; distribution of sediment & benthic communities; distribution of fish; influence of bottom currents	Lake Superior (Eastern half); Northern Lake Michigan; Eastern Lake Huron; Bering Sea	Standard Package; mapping; ROVs; subs; AUVs; sampling; moorings (ADCP)	Standard Partners

Great Lakes Workshop Results						
ID	**Category**	**Information Need/Gap**	**What**	**Where**	**Enabling Technologies**	**Partners**
270	Episodic Events	integrating in discoveries with accountability need, basic research with applied science; event driven storms, surface and benthic storms; distribution of nutrients, biomass & current influences	Distribution of nutrients; biomass & current influences	Costal harbor estuaries	Moorings (long term); high frequency surface radar (CODAR); ADCP's; development of ecological observatories with (beyond normal sensors); new engineering - adaptive sampling instruments	Standard Partners
278	Extreme Environments - Sea Ice	Charactering ecosystems and other systems	Ice dynamics surveys sampling; systematic surveys; four dimension; hydrothermal systems; long term sediment records; rates of change; seasonal ice covered areas	Deep basin to shallow water volumes; winter in Great Lakes	molecular systematics genetics (method to measure diversity); environmental tracers; miniaturized exploration / sampling techniques; fiber optics & subs; ROV's; AUV's; dynamic positioning systems	WHOI, Harbor Branch; National Geographic
287	Extreme Environments - Vents, Seeps & Volcanoes	High resolution spatial & temporal zooplankton measurement over space & time, classification	High resolution zooplankton measurement over space & time; classification	Compare Lake Superior and southern Lake Michigan; 10 largest lakes in the world; Yellowstone Lake	Bigger faster vessels (stationed in Lake Superior); optical plankton counter; towed vehicles; AUVs w/ zooplankton counter; in-situ genetic tech; video image classification tech	Standard Partners
296	Extreme Environments - Vents, Seeps & Volcanoes	Hydrothermal features in lake systems	Chemistry; microbiology; nutrient dynamics;	Crater Lake; Yellowstone Park lakes; African Lakes e.g. Tanganyika; Baikal	Miniaturized exploration / sampling techniques; fiber optics & subs; ROV's; AUV's; dynamic positioning systems	Standard Partners
298	Extreme Environments - Vents, Seeps & Volcanoes	Seeps/ non-oxygen environments - endemic species, evolution in isolation, inter-lake comparisons, genetics in large time scales	Endemic species; evolution in isolation; inter-lake comparisons; genetics in large time scales	North shore of Lake Superior; bays; nearshore; upper peninsula Superior; Ashland Port urban environment	Standard package	Standard Partners

Great Lakes Workshop Results						
ID	**Category**	**Information Need/Gap**	**What**	**Where**	**Enabling Technologies**	**Partners**
273	High Resolution Bathymetry	High resolution mapping of great lakes - survey of bottom of great lakes - shallow water mapping; extension of coastal estuaries & wetlands; understanding substrates to particle size; near-shore fossil coral reefs	Surveys; mapping; multibeam	Lake Superior; Lake Michigan; all the lakes; Yellowstone Lake (done this year); Crater Lake; African Lakes and other large Lakes; Mid-Lake Reefs; Mid-Lake ridge through Lake Huron; Lake Champlain	Standard Package; use of UNOLS w/multibeam; sub-bottom profiling; using side scanning sonar; seismic survey; hyperspectral imaging from aircraft; laser line scan; acoustic mapping; magnetometer; sub-bottom profiler; ROVs/subs	National Oceanographic Service; USACE; USGS; energy industry; museums
289	High Resolution Bathymetry	Mapping	Mapping; multibeam	Lake Superior; Lake Michigan; all the lakes; Yellowstone Lake (done this year); Crater Lake; African Lakes	Standard Package; Acoustic mapping; magnetometer; sub-bottom profiler; ROVs/subs	Standard Partners
269	Marine Organisms	Populations in flux; biological transitions zones	Linkages of rivers estuaries and basin; use of streams for spawning; ecosystems approach to water quality; examine revival of species; pollutants; identify organisms transitions zones; zebra mussel migrations; mapping of systems; transportation of organic and inorganic; identify organisms transitions zones; zebra mussel migrations; mapping of systems	Green Can Reef; Coastal areas; sea grasses; mangroves; Florida Bay	Time lapse; acoustic imaging of sediment layers; microscopic level	Standard Partners
284	Marine Organisms	Abyssal fish (> 50m)	Life history; impact of invasive species; spawning (where & how especially in winter season); character displacement behavior	Upper Great Lakes; Superior; Huron; Michigan; eastern basin of Lake Erie	Standard Package; ROVs; AUVs; time lapse camera systems planted on bottom in strategic locations; subs; acoustic scanner; long term video observation platform / time lapse cameras	Standard Partners, SIO; industry (esp. finances - power plants, fishing, fishing support); boating industry; Sea Grant Extension (outreach & funding); Jason Project

Great Lakes Workshop Results						
ID	**Category**	**Information Need/Gap**	**What**	**Where**	**Enabling Technologies**	**Partners**
295	Marine Organisms	How animals use vision & light to orient themselves in the water	Visible communication	Deep water; shallows; freshwater vs. saltwater	Standard Package; photon cameras	Standard Partners
297	Marine Organisms	Evolutionary biology; endemic species, evolution in isolation, inter-lake comparisons, genetics in large time scales	Endemic species; evolution in isolation; inter-lake comparisons; genetics in large time scales	Lake Victoria; Lake Malawi; other African lakes; Lake Baikal; compare w/ Great Lakes	Genetic tech; microbiology techniques; capture techniques	Standard Partners
268	Pelagic Environment	Pelagic habitat - ecosystem behavior's; both physical systems and benthic landscape; identifying boundary fluxes; identify microscale of physical / chemical processes; eddies & fronts; data mining & modeling	Intensify systems in time and space scale; global loss of biological diversity (loss of taxonomy and systematics skills) human technologies to resurrect core competence and knowledge; people & technological interface needed to continue the skills (greater diversity in program - mainly older / white males)	Biological hot-spots (Benthic & Pelagic Water Columns)	Sensors & Critter Cams - PSATS; Zoo Cam's; Fish Cams; buoy networks; upward looking devices to monitor water column; dockable AUV's; recycle oil rigs on mid-lake ridge; long term observatory	NWS; NESDIS; energy industry; Coast Guard, Navy; USACE; NSF, DOI, USGS; insurance industry
276	Pelagic Environment	Constant monitoring of pelagic community - buoy networks, or an upward looking devices to monitor water column	Buoy networks; or an upward looking devices to monitor water column	Lake Michigan for comparison of Older transects	Miniaturized exploration / sampling techniques; fiber optics & subs; ROV's; AUV's; dynamic positioning; more adaptive sensors following events	Standard Partners; WHOI, Harbor Branch; National Geographic
280	Pelagic Environment	Life in one cubic meter of water; seasonal change, species change, ID & characterize, transition rates, feeding rates, all of the rates	Seasonal change; species change; ID & characterize; transition rates; feeding rates; all of the rates	Contrast temperate vs. tropical; nearshore fresh vs. salt; contrast different parameters	Holography; acoustic doppler; dns; fluid simulation; IR laser scan (need low Reynolds# on machine); micro-chemical sensors; AUVs; ROVs; subs; sampling; neutrally buoyant chemostats	Standard Partners; Johns Hopkins University; University of Rhode Island

Great Lakes Region Exploration Targets of Interest

1. Africa's Great Rift Lakes - Malawi and Tanganyika (not on chart)
2. Crater Lake, Oregon (not on chart)
3. Death’s Door Passage
4. East African Rift Lakes - Lakes Edward, George, and Victoria (not on chart)
5. Great Bear Lake (not on chart)
6. Great Slave Lake (not on chart)
7. Green Bay
8. Green Can Reef
9. Keweenaw Peninsula
10. Lake Baykal (not on chart)
11. Lake Erie
12. Lake Huron
13. Lake Michigan
14. Lake Nicaragua (not on chart)
15. Lake Ontario
16. Lake Superior
17. Saginaw Bay
18. Straits of Mackinac
19. Titikacca Lake (not on chart)
20. Yellowstone Lake (not on chart)

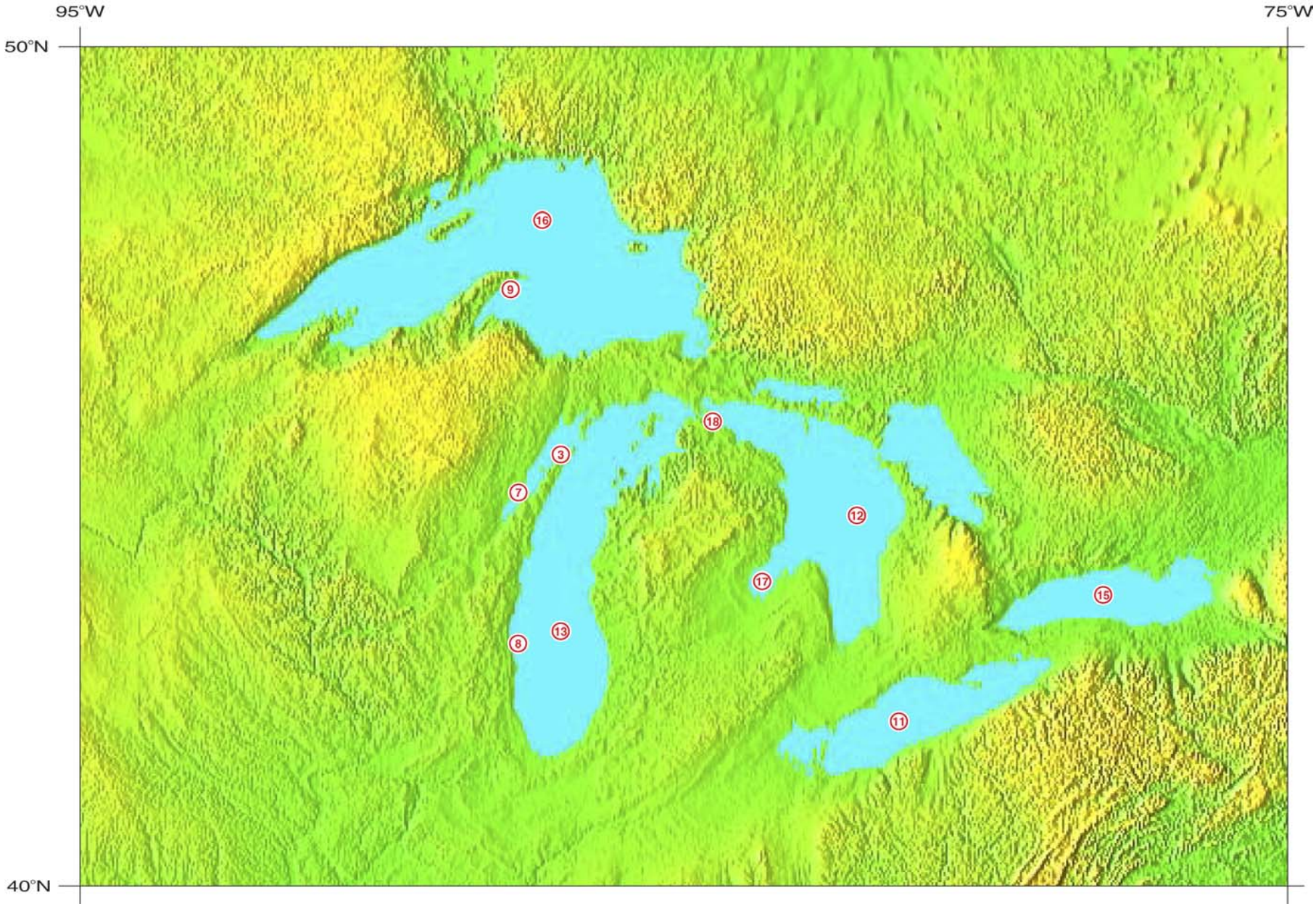

Figure 3-9. Great Lakes Region Exploration Targets of Interest